

Remarks

Claims 1-25 are pending. Claim 1 has been amended to incorporate the requirement of producing a material having at least two distinguishable physical states. Support for this element is found on page 4 of the published PCT application. Claim 16 has been amended to incorporate chemical structures in lieu of naming or identifying substituent groups and exclude compounds from the prior art. Claim 25 has been amended to expressly include the step of generating or processing the different conjugation steps in selected regions of a storage medium.

The Examiner rejects claims 16-24 under 35 U.S.C. 112(2) as being indefinite for failing to particularly point out and distinctly claim the subject matter that Applicants regard as the invention. The Examiner objects to the form of the exclusions in claim 16. The Examiner suggests inserting the chemical structures to clarify the intended compounds. The Examiner also objects to the phrase "1 and 2 or 3". Claim 16 has been amended to incorporate the chemical structures and delete the objectionable phrase.

The Examiner notes that claim 19 does not contain "n" in the formula. The formulae were drafted with handwritten "n" subscripts during the PCT prosecution. Claim 19 has been resubmitted with the subscripts in typeface.

Claim 1 is drawn to a method for information storage and data processing comprising the step of thermo-inducing or photo-inducing double-bond shifts in substituted [4n]-annulenes which are substituted by at least one group comprising an extended conjugated π -electron system which is in conjugation with the π -electron system of the [4n]-annulene core, thus generating transitions between two different conjugation states with at least one substituent. Claim 1 further includes the step of producing and/or processing a material having at least two distinguishable states. The latter step encompasses either the step of recording data on a storage medium or reading the data. Support for this element is found on page 4 of the published PCT application and as an inherent feature of the preamble intention to allow data processing. Claims 16 to 18 are drawn to novel compounds. Claims 19-22 are drawn to methods for manufacturing such compounds. Claims 23 and 24 are drawn devices including such novel compounds. Claim 25 is drawn to a method of information storage and data processing analogous to the scope of claim 1 but stated in a different

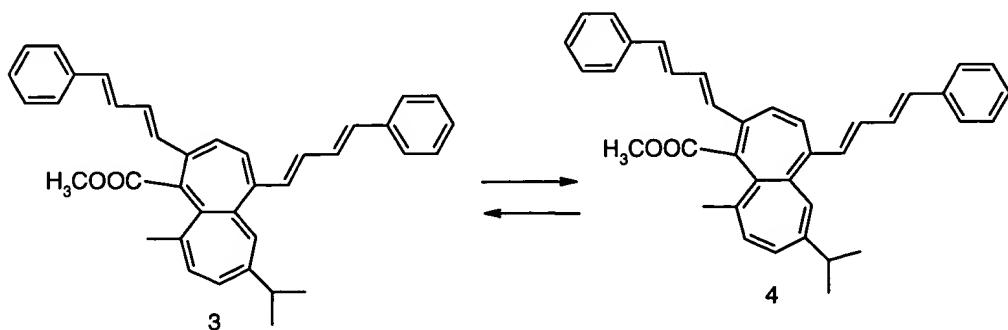
manner such that two different conjugation states are generated in selected portions of a storage material or the recorded data is processed.

The Examiner rejects claims 1, 2, 6, 7, 11-14 and 25 under 35 U.S.C. 102 as being anticipated by an article entitled "Triplet-State Cis-Trans Isomerizations of a Bisstyrylcyclooctatetraene", by Ingjald Anger et al., J. Phys. Chem. 99, 650-652 (D1). Applicants respectfully traverse this rejection.

D1 relates to the cis-trans isomerizations of Z,Z-, E,Z-, and E,E-1,5-bisstyryl-3,7-dimethylcyclooctatetraene. On triplet sensitized excitation, ZZ isomerized, via EZ as a ground-state intermediate, to EE with low quantum yields. D1 discloses neither double bond shifts in [4n]annulenes nor a method for information storage and data processing. D1 does not disclose or suggest producing an article having at least two distinguishable physical states or processing the information (claim 1) or generating/processing two different conjugation steps (claim 25). D1 does not anticipate claims 1, 2, 6, 7, 11-14 and 25.

The Examiner rejects claims 1-7, 12, 13, 16-18 and 23-25 under 35 U.S.C. 102 as being anticipated by an abstract entitled "Synthesis of New Photo- and Thermochromic Systems Based on Cyclic Double Bond Shifts in Heptalenes" H.-J. Hansen et al. Chimia vol. 50, pp. 341 (7/8-1996) (D2). The Examiner refers to formulae 3 and 4. Applicants respectfully traverse this rejection.

D2 discloses that heptalenes such as 3 and 4 are interconvertible through a double bond shift that can be induced thermo- or photochemically. 3 shows an intense absorption band at 433 nm which is not present in 4. Irradiation of 3 at 438 nm converts the compound into 4 which on standing at 25 °C slowly reverts to 3.



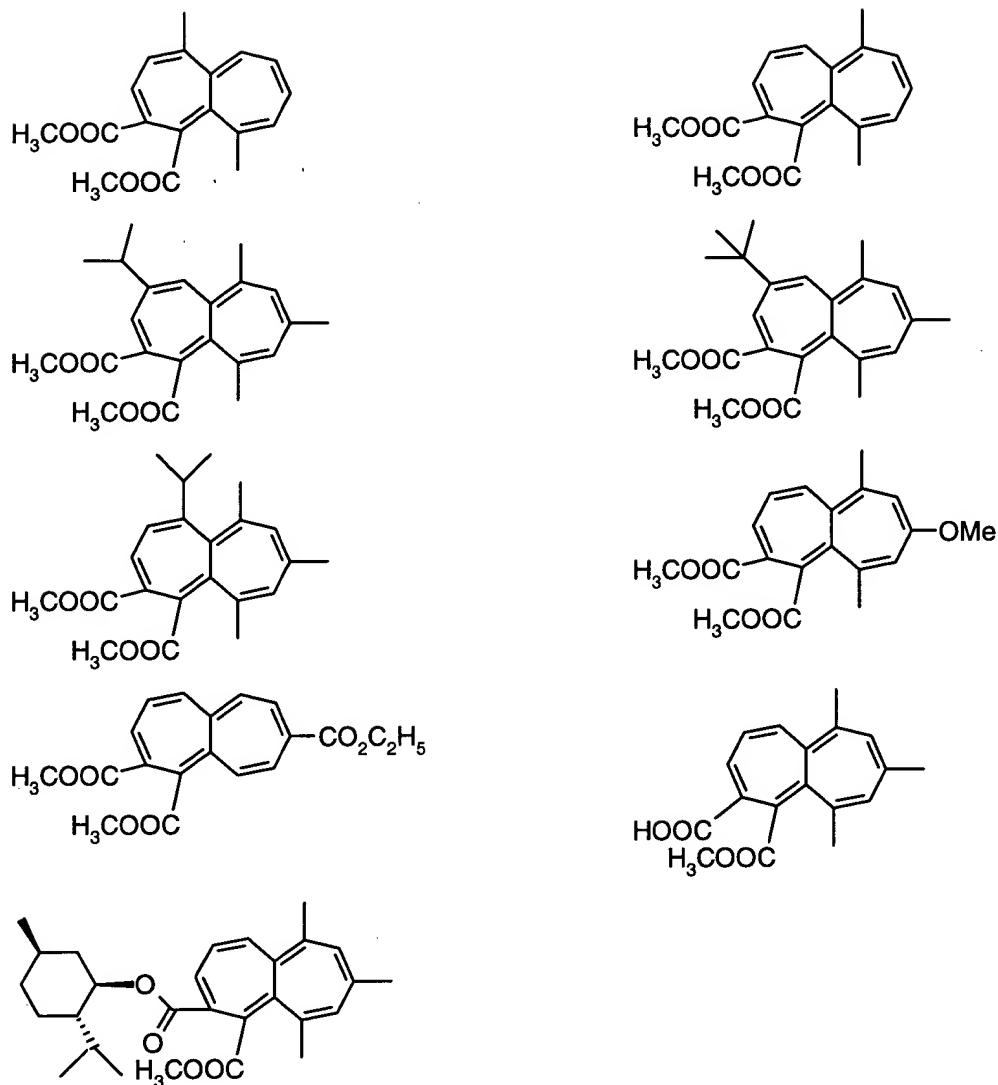
D2 does not provide sufficient information about the synthesis of 3 and 4. Moreover, the fact that different physical properties arises from the double bond shift (UV/Vis absorption) does not provide any information on the possibility to exploit 3 and 4 for information storage or data processing (cf. page 6, last paragraph of the present application). D2 does not disclose or suggest producing an article having at least two distinguishable physical states or processing the information (claim 1), the novel compounds of claim 16 or generating/processing two different conjugation steps (claim 25). D2 does not anticipate claims 1-7, 12, 13, 16-18 and 23-25.

The Examiner rejects claims 1-7, 12, 13 and 16-25 under 35 U.S.C. 102 as being anticipated by an article entitled "Double-Bond Shifts in [4n] Annulenes as a New Principle for Molecular Switches: First Results with Dimethyl Heptalene-1,2 and 4,5-dicarboxylates", by H.-J. Hansen et al., Helvetica Chimica Acta vol. 79, pp. 2282-2315 (1996) (D3). Applicants respectfully traverse this rejection.

The filing date of the present application is December 10, 1996. D3 is published on December 11, 1996, i.e. after the filing date of the present application and, therefore, D3 does not form prior art for the present application.

The Examiner rejects claims 1-7, 12, 13 and 16-25 under 35 U.S.C. 102 as being anticipated by an article entitled "Synthesis and Dynamic Behavior of Chiral Heptalenes", by Klaus Hafner et al., Bull. Chem. Soc. Jpn., vol. 61, pp. 155-163 (1988) (D4). Applicants respectfully traverse this rejection.

D4 teaches that cycloaddition reactions of azulenes with dimethyl acetylenedicarboxylate afford an excellent access to a large variety of substituted dimethyl 1,2-heptalenedicarboxylates. D4 does not disclose or suggest producing an article having at least two distinguishable physical states or processing the information (claim 1) or generating/processing two different conjugation steps (claim 25). The following compounds, which are mentioned on page 156 or 161 of D4, have been excluded from claim 16:

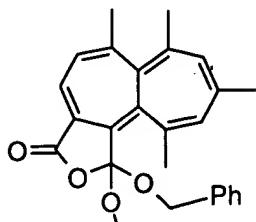


D4 does not anticipate claims 1-7, 12, 13 and 16-25.

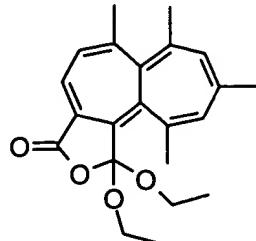
The Examiner rejects claims 1-7, 12, 13 and 16-25 under 35 U.S.C. 102 as being anticipated by an article entitled "Formation of Cyclic ortho-Anhydrides of Heptalene-1,2-dicarboxylic Acids", by H.-J. Hansen et al., Helvetica Chimica Acta, vol. 70, pp. 1439-1460 (1987) (D5). Applicants respectfully traverse this rejection.

D5 relates to the preparation of cyclic ortho-anhydrides of heptalene-1,2-dicarboxylic acids. D5 does not disclose or suggest producing an article having at least two distinguishable physical states or processing the information (claim 1) or generating/processing two different conjugation

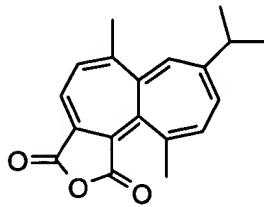
steps (claim 25). The following compounds, which are mentioned on page 1441 of D5, D13¹, and page 416 of D14², have been excluded from claim 16:



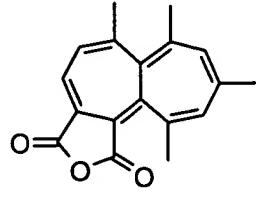
D5: page 1441



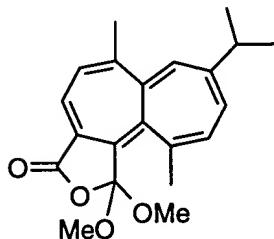
D14: page 416



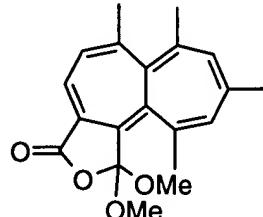
D13: page 744



D13: page 745



D13: page 746



D13: page 746

D5 does not anticipate claims 1-7, 12, 13 and 16-25.

The Examiner rejects claims 1, 2, 6, 7, 11-14 and 25 under 35 U.S.C. 102 as being anticipated by an article entitled "Ring Inversion and Bond Shifting Energetics in Substituted Chiral Cyclooctatetraenes", by Paquette, L.A., Pure Applied Chem., vol. 54(5), pp. 987-1004 (D6). Applicants respectfully traverse this rejection.

D6 discloses a new methodology which permits quantitative assessment of ring inversion and bond shifting barriers within [8]annulene derivatives, in particular chiral cyclooctatetraenes. D6 does not disclose or suggest producing an article having at least two distinguishable physical states or

¹ D13 is H.-J. Hansen et al., Helvetica Chimica Acta vol. 70, pp. 742-759 (1987).

² D14: H.-J. Hansen et al., Helvetica Chimica Acta vol. 68, pp. 429-438 (1985).

processing the information (claim 1) or generating/processing two different conjugation steps (claim 25). D6 does not anticipate claims 1, 2, 6, 7, 11-14 and 25.

The Examiner rejects claims 1, 2, 6, 7, 11-14 and 25 under 35 U.S.C. 102 as being anticipated by an article entitled "Novel pericyclic reactions in p-perimeter chemistry", by Hafner et al., Pure Applied Chem., vol. 65(1), pp. 17-25 (1993) (D7). Applicants respectfully traverse this rejection.

D7 relates to the synthesis and rearrangement of 5, 5a, 10, 10a-tetrahydroheptalene derivatives. D7 does not disclose or suggest producing an article having at least two distinguishable physical states or processing the information (claim 1) or generating/processing two different conjugation steps (claim 25). D7 does not anticipate claims 1, 2, 6, 7, 11-14 and 25.

The Examiner rejects claims 1-9, 11-14 and 16-25 under 35 U.S.C. 103 as being unpatentable over D2 or D3 in view of U.S. Pat. No. 5,438,561 (D9). D9 is cited as showing the use of photochromic compounds in polymeric binders. The Examiner alleges that it would be obvious to use the photochromic compounds shown in D2 or D3 in polymeric binders. Applicants respectfully traverse this rejection.

D3 is published after the filing date of the present application and, therefore, does not form prior art for the present application. D2 does not provide sufficient information about the synthesis of 3 and 4. Moreover, the fact that different physical properties arises from the double bond shift (UV/Vis absorption) does not provide any information on the possibility to use 3 and 4 for data processing (cf. page 6, last paragraph of the present application). D9 relates to a method for recording and reproducing information using an optical memory device being constituted by a transparent substrate, a recording film formed on the substrate and made of a resin containing a photochromic material dispersed therein. Specific examples of the photochromic material are diarylethene derivatives and nitrospirothiopyran. However, D9 (as well as D2) does not contain any hint that substituted [4n]annulenes can be used in a method for information storage and data processing.

The Examiner rejects claims 1-9, 12 and 16-25 under 35 U.S.C. 103 as being unpatentable over D2 or D3 in view of U.S. Pat. No. 5,432,873 ("D10"). D10 is cited as showing the use of photochromic compounds in optical switches. The Examiner alleges that it would be obvious to use the photochromic compounds shown in D2 or D3 in optical switches. Applicants respectfully traverse this rejection.

D3 is published after the filing date of the present application and, therefore, does not form prior art for the present application. D10 relates to an optical switch in which a compound including a photochromic material is placed between two optical waveguides. According to D10 examples of photochromic materials are derivatives of fulgide, anthracene, azobzene, hydrazine, oxazone, diarylethene, salicylaldehyde, spiropyran, biimidazolyl and cyclophan (see D10, column 6, line 18 to 21). According to D10, column 5, line 61 to column 6, line 21 the photochromic material must meet specific conditions to be suitable for the optical switch according to D10. That is, not any photochromic material is suitable for information storage and data processing. Consequently, D10 does not teach or suggest the use of substituted [4n]annulenes in a method for information storage and data processing. D2 is distinguished for the same reasons given above.

The Examiner rejects claims 1-7, 10, 12 and 16-25 under 35 U.S.C. 103 as being unpatentable over D2 or D3 in view of an extract from "The Applications of Holography", by H.J. Caulfield et al. (D11). D11 is cited as showing that photochromic holography medium are conventional or well-known. The Examiner alleges that it would be obvious to use the photochromic compounds shown in D2 or D3 in holographic media. Applicants respectfully traverse this rejection.

D11 contains a general disclosure that various recording media, including photochromic materials, have been used for holographic recording. No specific photochromic materials are mentioned in D11, however. Therefore, D11 does not teach the use of substituted [4n]annulenes in a method for information storage and data processing. D2 and D3 are distinguished for the same reasons given above.

Applicants submit that the instant application is now in condition for allowance. In the event that minor amendments will further prosecution, Applicants request that the Examiner contact the undersigned representative.

Respectfully submitted,



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Claims with Mark-Up

1. (amended) Method for information storage and data processing comprising the step of thermo-inducing or photo-inducing double-bond shifts in substituted [4n]-annulenes which are substituted by at least one group comprising an extended conjugated π -electron system which is in conjugation with the π -electron system of the [4n]-annulene core, thus generating transitions between two different conjugation states with at least one substituent to produce and/or process a material having at least two distinguishable physical states.

2. Method according to claim 1, whereby the two different conjugation states are the conjugation on-state and conjugation off-state of the annulene core π -electrons relative to the substituent π -electrons.

3. Method according to claim 1, whereby said [4n]-annulenes are bicyclic [4n]-annulenes.

4. Method according to claim 3, whereby said bicyclic [4n]-annulenes are heptalenes.

5. Method according to claim 1, whereby the [4n]-annulenes are substituted in 1,2- or 1,4-position relative to each other by two groups having an extended and conjugated π -electron system.

6. Method according to claim 1, whereby a multitude of [4n]-annulene molecules are arranged in a 1-dimensional or in a 2-dimensional or in a 3-dimensional way and wherein said conjugation states are spacially non-uniformly modulated.

7. Method according to claim 6, whereby a conformationally restricted matrix system is generated by modulating said conjugation states.

8. Method according to claim 1, whereby the [4n]-annulene molecules are embedded in a matrix.

9. Method according to claim 8, wherein the matrix comprises a low-melting glass or polycarbonates, polyacetates, methacrylates, styrenes and copolymers thereof, as well as copolymers with polymerisable [4n]-annulenes.

10. Method according to claim 6, whereby a holographic grating is generated by modulating said conjugation states.

11. Method according to claim 6, wherein the spacially non-uniformly modulated conjugation states are generated by a low-energy laser that provides for a local heating so bring the [4n]-annulenes into switching condition and whereby the laser light causes locally, if required, the switch from the conjugative on-state to the conjugative off-state.

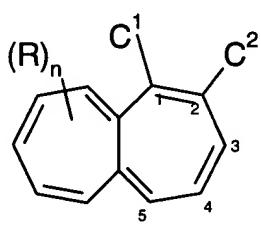
12. Method according to claim 5, comprising further to said step of modulating a multitude of [4n]-annulene molecules in a 1-dimensional or 2-dimensional or 3-dimensional way and wherein said conjugation states are spacially non-uniformly modulated, a further step wherein at least one of the optical, electrical or magnetic properties being attributable to said switchable conjugation states is determined and processed.

13. Method according to claim 1, wherein said conjugation states are determined by an optical read-out step.

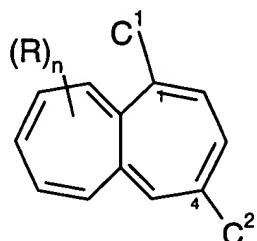
14. Method according to claim 1, wherein the determination of the spatially non-uniformly modulated conjugation states is used for the optical reading of information.

15. Method according to claim 1, wherein the determination of the spatially non-uniformly modulated conjugation states is used for optical switching and computing.

16. (**amended**) Substituted [4n]-heptalenes of the general formula (I) or (II) being optically and/or thermally switchable, based on thermal or photochemical double-bond shifts,



(I)

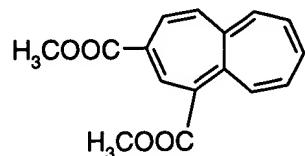
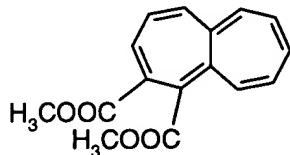


(II)

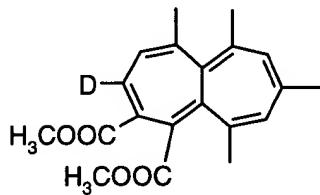
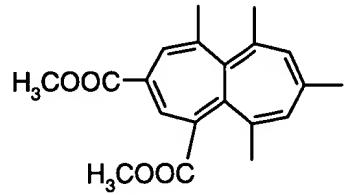
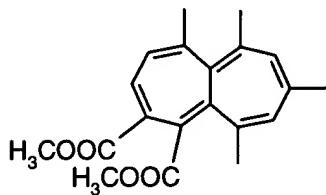
whereby C¹ and C² represent independently from each other a hydrogen atom, a substituted or unsubstituted C₁-C₁₂-alkyl group, a substituted or unsubstituted C₁-C₁₂-alkoxy group, a substituted or unsubstituted aryl-C₁-C₁₂-alkyl group, a substituted or unsubstituted C₁-C₁₂-alkenyl group, a substituted or unsubstituted C₁-C₁₂-conjugated alkenyl group, a substituted or unsubstituted C₁-C₁₂-alkinyl group, a substituted or an unsubstituted phenyl group, a substituted or an unsubstituted heterocyclic group, a cyano group, a nitro group, a thiocyanate group, a C₁-C₁₂-ester group being optionally polymerisable with copolymers, with the proviso that at least one of said substituents C¹ and C² contains a π -electron system which is in conjugation with the π -electron system of the heptalene core, and whereby said [4n]-heptalenes can comprise at least one further substituent R being selected from the above indicated groups with n being 0-8,

provided that if one of the at least one further substituents R is an (a) isopropyl group at the position 9 of the heptalene ring, the substituent at the position 6 must not be a methyl group, and

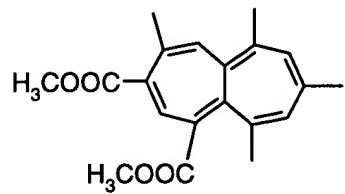
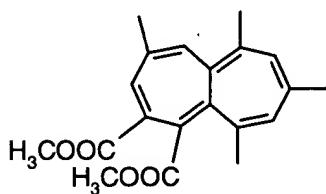
with the proviso that heptalenes having the following substituents formulae including their valence isomers are excluded :



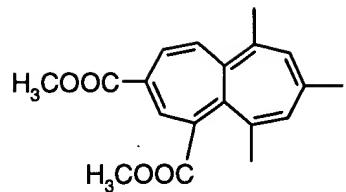
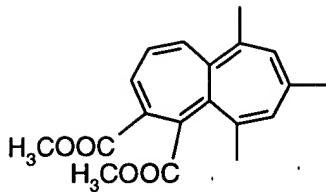
~~the positions 1 and 2 or 3 are substituted by a methylester group, whereby R is H,~~



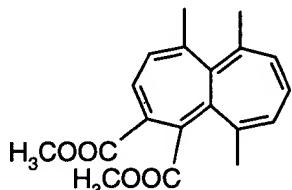
~~the positions 1 and 2 or 3 are substituted by a methylester group or position 3 could be substituted by deuterium and the positions 5, 6, 8 and 10 are substituted by a methyl group,~~



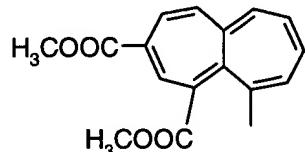
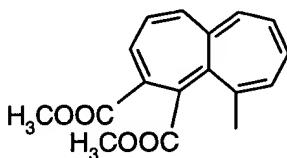
~~the positions 1 and 2 or 3 are substituted by a methylester group and the positions 4, 6, 8 and 10 are substituted by a methyl group,~~



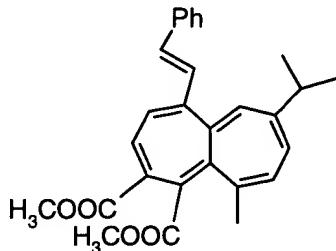
the positions 1 and 2 or 3 are substituted by a methylester group and the positions 6, 8 and 10 are substituted by a methyl group,



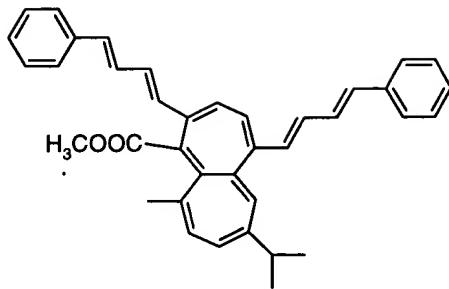
~~the positions 1 and 2 are substituted by
positions 5, 6 and 10 are substituted by~~



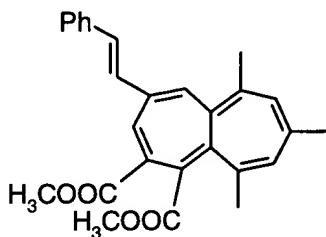
the positions 1 and 2 or 3 are substituted by a methylester group and the position 10 is substituted by a methyl group,



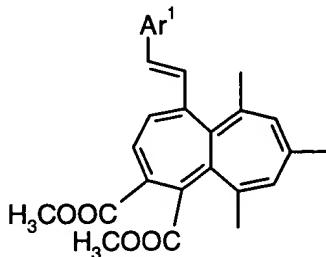
the positions 1 and 2 are substituted
position 5 is substituted by a styrene
stituted by a isopropyl group and the
a methyl group,



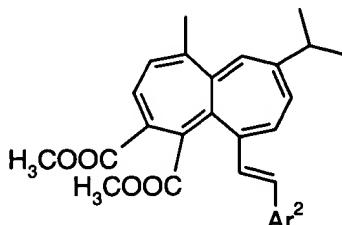
the position 1 is substituted by a methylester group, the positions 2 and 5 are substituted by a $\text{CH}=\text{CH}-\text{CH}=\text{CH}-\text{C}_6\text{H}_5$ group, position 7 is an isopropyl and position 10 a methyl group,



the positions 1 and 2 are substituted by a methylester group, the position 4 is substituted by a styrene group and the positions 6, 8 and 10 are substituted by a methyl group,

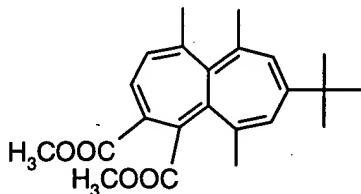


Ar^1 = phenyl, 4-chloro phenyl or 4-methoxy phenyl, the positions 1 and 2 are substituted by a methylester group, the position 5 is substituted by a styrene group or a 4-chloro styrene group or a 4-methoxy styrene group, and the positions 6, 8 and 10 are substituted by a methyl group,

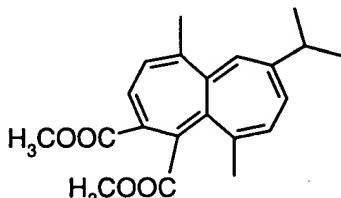


Ar^2 = phenyl or 4-methoxy phenyl,

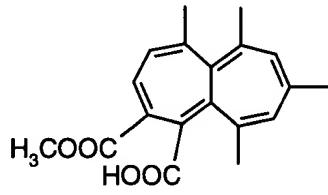
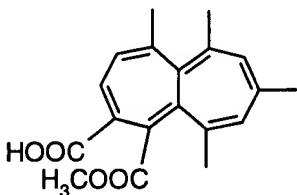
the positions 1 and 2 are substituted by a methylester group, the position 5 is substituted by a methyl group, the position 7 is substituted by an isopropyl group and the position 10 is substituted by a 4-methoxy styrene group or a styrene group,



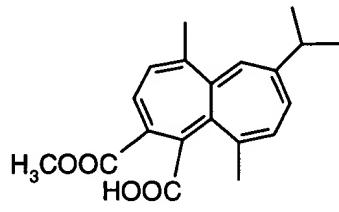
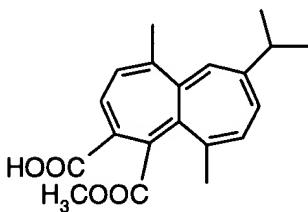
the positions 1 and 2 are substituted by a methylester group, the positions 5, 6 and 10 are substituted by a methyl group and the position 8 is substituted by an isobutyl group,



the positions 1 and 2 are substituted by a methylester group, the positions 5 and 10 are substituted by a methyl group and the position 7 is substituted by an isopropyl group,

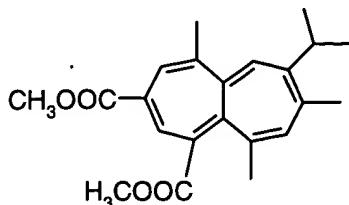


the position 1 is substituted by a methylester group, the position 2 is substituted by a carboxylic acid group or vice versa, and the positions 5, 6, 8 and 10 are substituted by a methyl group,

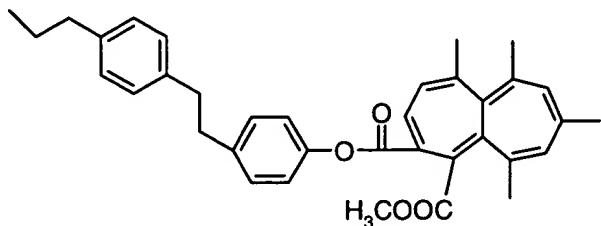


the position 1 is substituted by a methylester group, the position 2 is substituted by a carboxylic acid group or vice versa,

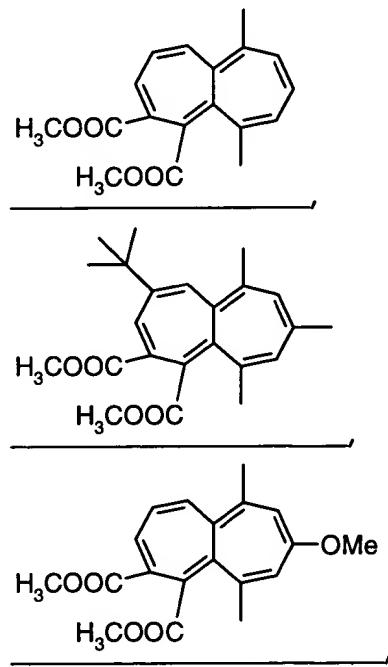
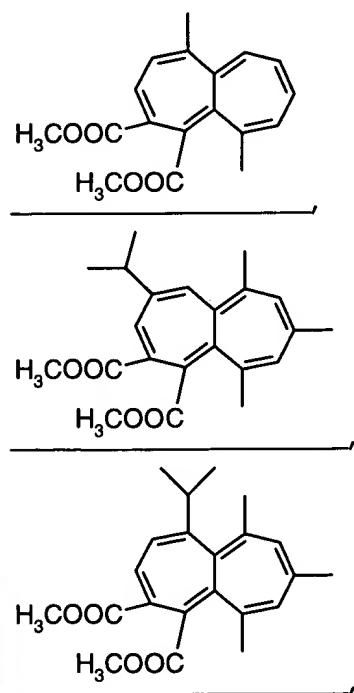
the positions 5 and 10 are substituted by a methyl group and the position 7 is substituted by an isobutyl group,

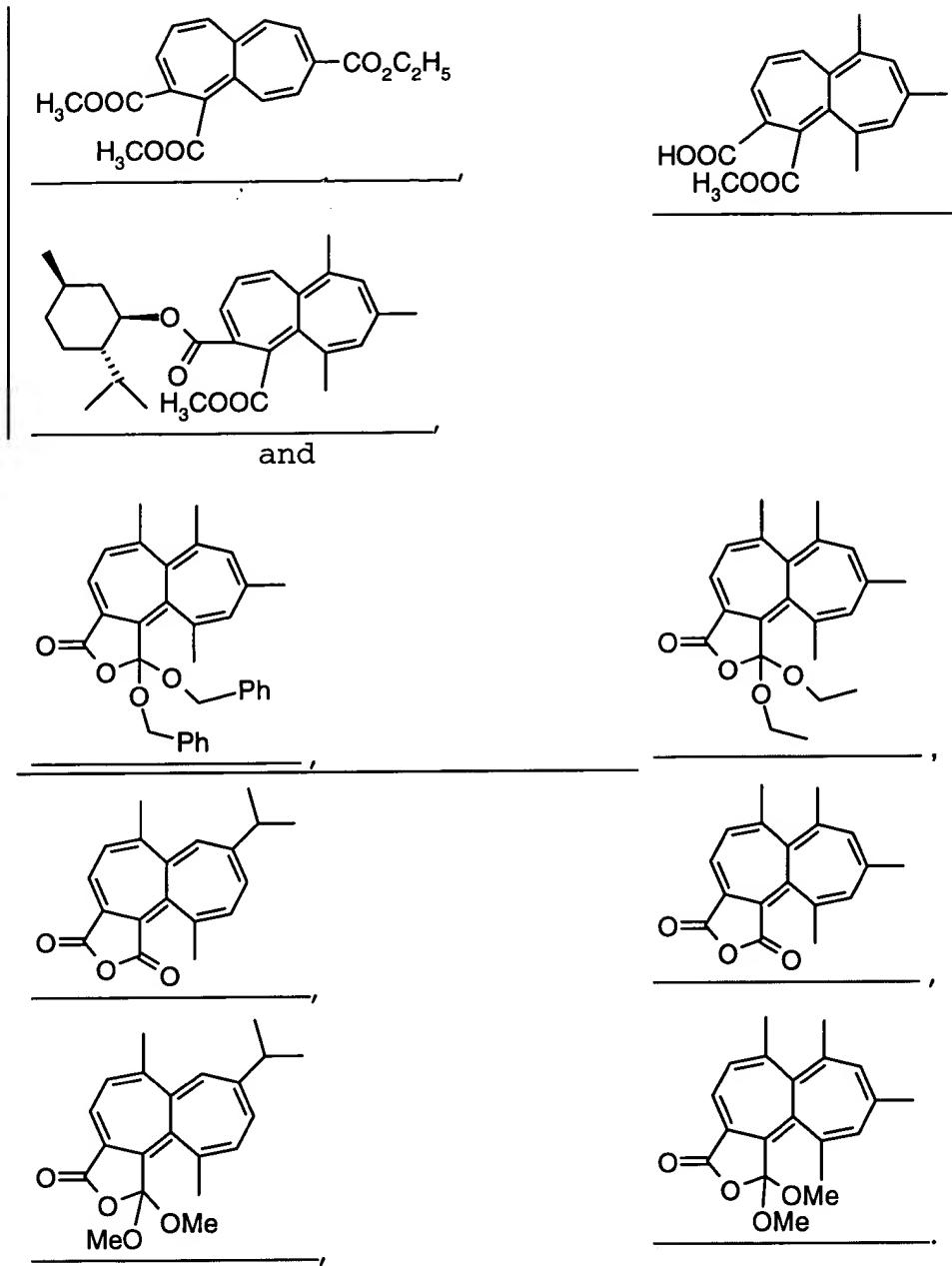


the positions 1 and 3 are substituted by a methyl ester group, the position 7 is substituted by an isopropyl group and the positions 8 and 10 are (is) substituted by a methyl group,



the position 1 is substituted by a methyl ester group, the position 2 is substituted by a $\text{CH}_3(\text{CH}_2)_2(1,4)\text{C}_6\text{H}_{10}(\text{CH}_2)_2(1,4)\text{C}_6\text{H}_{10}\text{OCO}$ group and the positions 5, 6, 8 and 10 are substituted by a methyl group and



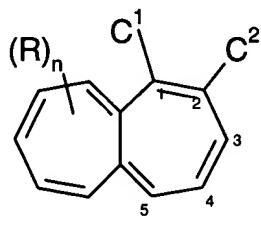


17. [4n]-heptalenes according to claim 16, whereby, C¹ and C² represent independently from each other a hydrogen atom, a methyl group, a phenyl group, an ethyl ester group, a methyl ester group, a (E)-PhCH=CH-group, a (E)-4-MeOC₆H₄CH=CH-group, a (E)-4-C1C₆H₄CH=CH-group, a 4-MeOC₆H₄-group, a -CH=CH-CH=CH-C₆H₅ group, a -CH=CH-C₆H₄NO₂-4 group, a -CH=CH-C₆H₄OMe-4 group, with the proviso that a heptalene being substituted by a methyl ester group at the position

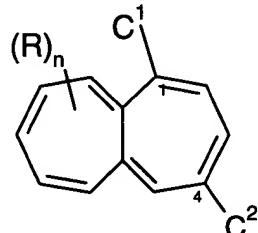
1, a $-\text{CH}=\text{CH}-\text{CH}=\text{CH}-\text{C}_6\text{H}_5$ group at the positions 2 and 5, an isopropyl group at the position 7 and a methyl group at the position 10 is excluded.

18. [4n]-heptalenes according to claim 16, whereby said further substituents R are selected from the group comprising substituted or unsubstituted $\text{C}_1\text{-C}_{12}$ -alkyl groups or photoactive diazo-containing groups, like azobenzene.

19. (**resubmitted**) Method for the preparation of substituted heptalenes of the formula (I) or (II), according to claim 16



(I)



(II)

whereby C^1 , C^2 , R and n are as above defined, comprising the steps of

(a) obtaining a heptalene-dicarboxylate by a reaction of a correspondingly substituted azulene with acetylenedicarboxylate, and optionally

(b) transforming at least one carboxylic group or another substituent that was entered by the preliminary Diels-Alder reaction into the desired conjugated substituent having an extended π -electron system.

20. Method according to claim 19, whereby a heptalene-4,5-dicarboxylate carrying a methyl substituent at the position 1 of the heptalene ring is obtained.

21. Method according to claim 19, further comprising a step (c) wherein at least one of the carboxolate groups within the heptalene ring is replaced by a conjugated substituent containing an extended π -electron system.

22. Method according to claim 21, wherein the carboxylate group at the position 4 of the heptalene ring is replaced by a conjugated substituent containing an extended π -electron system.

23. An optical storage device comprising at least one substituted [4n]-annulene according to claim 16.

24. A non-linear optical device comprising at least one substituted [4n]-annulene according to claim 16.

25. (**amended**) Process of information storage and data processing by using substituted [4n]-annulenes which are substituted by at least one group comprising an extended conjugated π -electron system which is in conjugation with the π -electron system of the [4n]-annulene core undergoing thermally induced or photo-induced double-bond shifts thus generating or processing previously generated at least two different conjugation states with at least one substituent in selected regions of storage medium.